COMPSCI 110

Mid-Semester Test Solutions

Sem1 2020

Question 1

Which of the following additions are correct? Subscripts have been used to indicate the base of the numbers involved.

1. $4C2_{16} + 36B_{16} = 82D_{16}$
2. $23_8 + 54_8 = 77_8$
3. $467_8 + 654_8 = 1343_8$
4. $FAB_{16} + DDE_{16} = 1C89_{16}$
5. $5CEA_{16} + 3FFF_{16} = 9CE9_{16}$

Select one:

- a. 1, 4, and 5
- b. 2, 3 and 4
- c. 1, 2, 3 and 5
- d. 2 and 4
- e. 1, 2, 4 and 5

Question 2

Which of the following subtractions are correct? Subscripts have been used to indicate the base of the numbers involved.

1. $2103_{16} - FED_{16} = 116_{16}$
2. $3210_8 - 2645_8 = 343_8$
3. $7135_8 - 4677_8 = 2450_8$
4. $21006_8 - 7777_8 = 11007_8$
5. $8B976_{16} - CDEF_{16} = 7EB87_{16}$

Select one:

- a. 3 and 4
- b. 1, 3, 4 and 5
- c. 1, 2 and 3
- d. 1 and 3
- e. 2, 4 and 5

Question 3

Which of the following statements about signed integers are correct?

1. With a 10 bit 1's complement representation, the smallest number you can represent is -512.
2. With a 12 bit 2's complement representation, the smallest number you can represent is -2048.
3. With an 11 bit sign-magnitude representation, the largest number you can represent is 1048.
4. With an 8 bit 2's complement representation, the largest number you can represent is 128.
5. With a 13 bit 1's complement representation, the largest number you can represent is 4095.

Select one:

- a. 2, 3 and 4
- b. 1 and 3
- c. 2 and 5
- d. 1, 3 and 4
- e. 3 and 4

Question 4

Which of the following decimal fractions can be represented as binary fractions with a finite number of bits?

1. 0.09375
2. 0.85
3. 0.53125
4. 0.275
5. 0.1025

Select one:

- a. 1, 2 and 5
- b. 2, 4 and 5
- c. 1 and 3
- d. 2 and 4
- e. 4 and 5

Question 5

Which of the following boolean expressions would give the truth table below?

A	B	C	Output
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	0

Select one:

- a. $\overline{A}\cdot\overline{B}\cdot\overline{C} + \overline{A}\cdot B\cdot\overline{C} + A\cdot\overline{B}\cdot\overline{C}$
- b. $\overline{A}\cdot\overline{B}\cdot C + \overline{A}\cdot B\cdot C + A\cdot\overline{B}\cdot C$
- c. $A\cdot\overline{B}\cdot C + A\cdot B\cdot\overline{C} + A\cdot B\cdot C$
- d. $\overline{A}\cdot B\cdot C + A\cdot\overline{B}\cdot\overline{C} + A\cdot B\cdot\overline{C}$
- e. $\overline{A}\cdot B\cdot\overline{C} + A\cdot\overline{B}\cdot\overline{C} + A\cdot B\cdot\overline{C}$

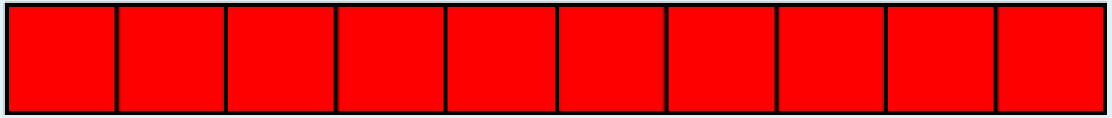
Question 6

In lectures we discussed how bitmap images are stored as a grid of pixel values. Each pixel has a colour value, and colour can be encoded using the RGB encoding scheme.

In lectures we also discussed using the RLE compression technique. Examples of the RLE technique being used to compress text were given. Instead of storing every single character individually, if there is a sequential run of identical characters, data on one character is stored along with a count of the number of occurrences of that character. Therefore text like "AAAABBB" could be compressed using the RLE technique to "A4B3".

For the next two questions we will look at using this same RLE technique for compressing image data. We can store the colour value for one pixel, followed by an integer value indicating how many sequential pixels with the same colour value there are.

Look at the bitmap image below. Each square represents a pixel. The colour value for each pixel will be encoded using the RGB encoding scheme. You can assume that a 16 bit integer value will be used to indicate the number of sequential pixels with the same colour value.



How much memory, in **bytes**, will be required to store the image above **uncompressed**? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols.

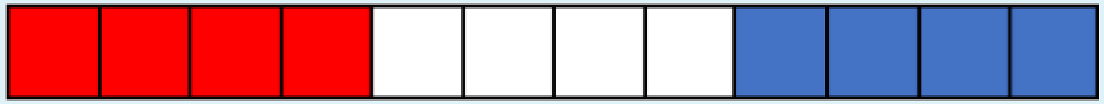
30

How much memory, in bytes, will be required to store the image if we compressed it using the RLE compression technique discussed? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols. 5

What compression ratio have we achieved? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols. 6

Question 7

Look at the bitmap image below. Each square represents a pixel. The colour value for each pixel will be encoded using the RGB encoding scheme. You can assume that a 16 bit integer value will be used to indicate the number of sequential pixels with the same colour value.



How much memory, in **bytes**, will be required to store the image above **uncompressed**? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols.

36

How much memory, in **bytes**, will be required to store the image if we **compressed** it using the **RLE** compression technique discussed? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols. 15

What compression ratio have we achieved? Please answer with a decimal value. Do not use any spaces, punctuation, letters or symbols. 2.4

Question 8

Assume that the memory on a system is organized as a two-dimensional grid with 1024 rows and 65536 columns. Also, assume that each memory cell is 24-bits wide. Answer the questions on this page (8 - 15) based on these facts.

All questions require a numerical answer. Do not use alphabetical characters, spaces or any punctuation.

How many bits are needed for the MAR register on such a system?

Answer: 26

Question 9

How many input lines will the row decoder have on such a system?

Answer: 10

Question 10

How many output lines would a row decoder have on such a system?

Answer: 1024

Question 11

How many input lines would a column decoder have on such a system?

Answer: 16

Question 12

How many output lines would a column decoder have for such a system?

Answer: 65536

Question 8

Assume that the memory on a system is organized as a two-dimensional grid with 1024 rows and 65536 columns. Also, assume that each memory cell is 24-bits wide. Answer the questions on this page (8 - 15) based on these facts.

All questions require a numerical answer. Do not use alphabetical characters, spaces or any punctuation.

How many bits are needed for the MAR register on such a system?

Answer: 26

Question 13

What is the memory address space of this system?

Answer: 671088(

67108864

Question 14

What is the largest possible address on such a system? Express your answer in decimal.

Answer: 671088(

67108863

Question 15

What should the size of the MDR register be (in terms of number of bits) on such a system?

Answer: 24

Question 16

Assume that the size of the instruction register on a machine is 32 bits. Answer the questions on this page (16 - 18) based on this fact. All questions require a numerical answer. Do not use alphabetical characters, spaces or any punctuation.

How many possible instructions can this machine have, assuming that it uses 8 bits of the instruction for the opcode?

Answer: 256

Question 17

Assume that the instruction format for the machine architecture described in Question 16, uses direct addressing mode, like the following:

ADD	X

What will be the address space of such a machine?

Answer: 167772

16777216

Question 18

Next, assume that the machine with the architecture details as in Question 16 were to support instructions of the following format:

ADD	R1	R2	R3

How many possible registers could the machine have for holding operands to be used by the ALU?

Answer: 256

Question 19

Read the following pseudocode and answer the question that follows:

```
get input1
get input2
stop ← input1
factor ← input2
value ← 1
count ← 1
sum ← 0
while count ≤ stop
    sum ← sum + value
    value ← value * factor
    count ← count + 1
end while
print sum
```

What is the output of this program when the inputs are 5 and 3 (in that order)?

Answer: 121

Question 20

Read the following pseudocode and answer the questions that follow:

```
get number
count ← 1
value ← 0
stop ← number
while count ≤ stop
    value ← value + count
    count ← count + 1
end while
print value
```

What is the output of the program when the input is 10?

Answer: 55

Question 21

Read the following assembly language program written using the textbook architecture. The comments at the right end of each line are for numbering the lines. The program starts at address zero.

```
        .BEGIN                    -- line 1
        IN          X             -- line 2
        IN          Y             -- line 3
        IN          Z             -- line 4
        IN          N             -- line 5
START:  LOAD        COUNT         -- line 6
        COMPARE     N             -- line 7
        JUMPEQ      STOP          -- line 8
        LOAD        X             -- line 9
        ADD         X             -- line 10
        STORE       TEMP          -- line 11
        LOAD        Y             -- line 12
        ADD         Y             -- line 13
        ADD         TEMP          -- line 14
        SUBTRACT    Z             -- line 15
        STORE       TEMP          -- line 16
        INCREMENT   COUNT         -- line 17
        JUMP        START         -- line 18
STOP:   OUT         TEMP          -- line 19
        HALT                      -- line 20
X:      .DATA       0             -- line 21
Y:      .DATA       0             -- line 22
Z:      .DATA       0             -- line 23
N:      .DATA       0             -- line 24
TEMP:   .DATA       0             -- line 25
COUNT:  .DATA       0             -- line 26
        .END                      -- line 27
```

Write the machine code for each of the following lines. Enter your answers as **exactly 4 digit hexadecimal numbers**. Do not use spaces, punctuation or symbols. Answers are not case sensitive. If there are any leading zeros, you need to put them in the answers. The first one has been done for you.

Line 6 -	0018
Line 7 -	7016
Line 8 -	A011
Line 15 -	5015
Line 26 -	0000

Question 22

Read the following assembly language program written using the textbook architecture. The comments at the right end of each line are for numbering the lines. The program starts at address zero.

```
        .BEGIN                          -- line 1
L:      IN          X                   -- line 2
        LOAD        X                   -- line 3
        ADD         X                   -- line 4
        STORE       Y                   -- line 5
        ADD         Y                   -- line 6
        COMPARE     Z                   -- line 7
        JUMPLT      L                   -- line 8
        OUT         X                   -- line 9
        HALT                            -- line 10
X:      .DATA       0                   -- line 11
Y:      .DATA       0                   -- line 12
Z:      .DATA       4                   -- line 13
        .END                            -- line 14
```

Write the machine code for each of the following lines. Enter your answers as **exactly 4 digit hexadecimal numbers**. Do not use spaces, punctuation or symbols. Answers are not case sensitive. If there are any leading zeros, you need to put them in the answers.

Line 2 -	D009
Line 6 -	300A
Line 5 -	100A

Question 23

```
.BEGIN
IN        X
IN        Y
LOAD      X
ADD       X
ADD       X
STORE     X
LOAD      Y
ADD       Y
STORE     Y
LOAD      X
SUBTRACT  Y
STORE     X
OUT       X
HALT

X: .DATA  0
Y: .DATA  0
.END
```

Desk check the above assembly program using an input value of 5 and 4 (in that order).
Show the values of all the labelled data locations, the value of the R register and any output values using the table below.
If a value changes, enter the value in the next cell on the same row.

R:	?	5	10	15	4	8	15	7
X:	0	5	15	7				
Y:	0	4	8					
Output:	7							

Question 24

```
        .BEGIN
        IN         N

START:  LOAD       TERM
        COMPARE    N
        JUMPLT     FINISH
        ADD        SUM
        STORE      SUM
        INCREMENT  TERM
        JUMP       START

FINISH: OUT        SUM
        HALT

N:      .DATA      0
TERM:   .DATA      1
SUM:    .DATA      0
        .END
```

Desk check the above assembly program using an input of 8.
Show the values of all the labelled data locations, the value of the R register and any output values using the table below.
If a value changes, enter the value in the next cell on the same row.

R:	?	1	2	3	6	4	10	5	15	6	21	7	28	8	36	9
N:	0	8														
TERM:	1	2	3	4	5	6	7	8	9							
SUM:	0	1	3	6	10	15	21	28	36							
Output:	36															

At the HALT instruction in the program above, what are the values of condition codes GT, LT, and EQ? Answer using the table below.

GT:	0
LT:	1
EQ:	0

Question 25

Here is a machine code program using the textbook assembly language. The addresses are given in the left margin in decimal for each memory cell.

```
0:  1101  0000  0000  1001
1:  0000  0000  0000  1000
2:  0011  0000  0000  1001
3:  0001  0000  0000  1001
4:  0111  0000  0000  1010
5:  1011  0000  0000  0000
6:  1110  0000  0000  1000
7:  1111  0000  0000  0000
8:  0000  0000  0000  0011
9:  0000  0000  0000  0000
10: 0000  0000  0000  0000
```

Using this program, write the correct assembly language instructions for the specified addresses. Opcodes are not case sensitive.

Address 1:	LOAD	8
Address 4:	COMPARE	10
Address 0:	IN	9

Question 26

Here is a machine code program using the textbook assembly language. The addresses are given in the left margin in decimal for each memory cell.

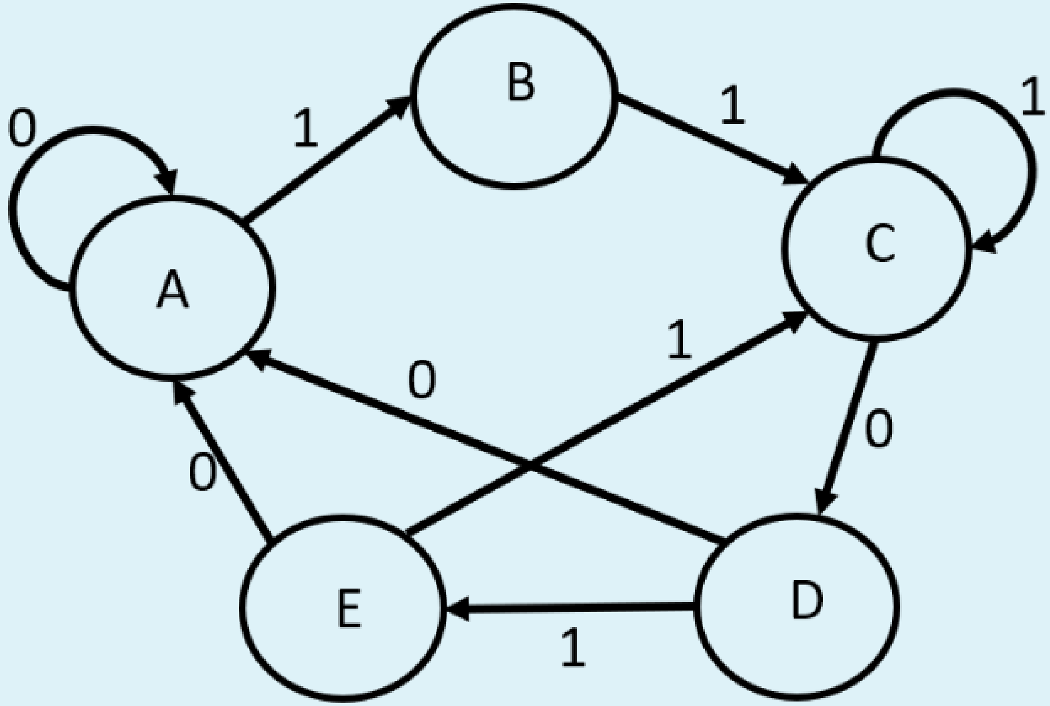
```
0:  1101  0000  0000  1011
1:  0000  0000  0000  1101
2:  0011  0000  0000  1100
3:  0001  0000  0000  1101
4:  0110  0000  0000  1011
5:  0000  0000  0000  1011
6:  0111  0000  0000  1110
7:  1010  0000  0000  1001
8:  1000  0000  0000  0001
9:  1110  0000  0000  1101
10: 1111  0000  0000  0000
11: 0000  0000  0000  0000
12: 0000  0000  0000  0100
13: 0000  0000  0000  0000
14: 0000  0000  0000  0000
```

Using this program, write the correct assembly language instructions for the specified addresses. Opcodes are not case sensitive.

Address 3:	STORE	13
Address 2:	ADD	12
Address 9:	OUT	13

Question 27

Study the state machine diagram given below and answer the questions that follow.



Answer each of the following question with the name of a state - A to E. Answers are not case sensitive. Do not use any other characters, spaces, punctuation marks etc.

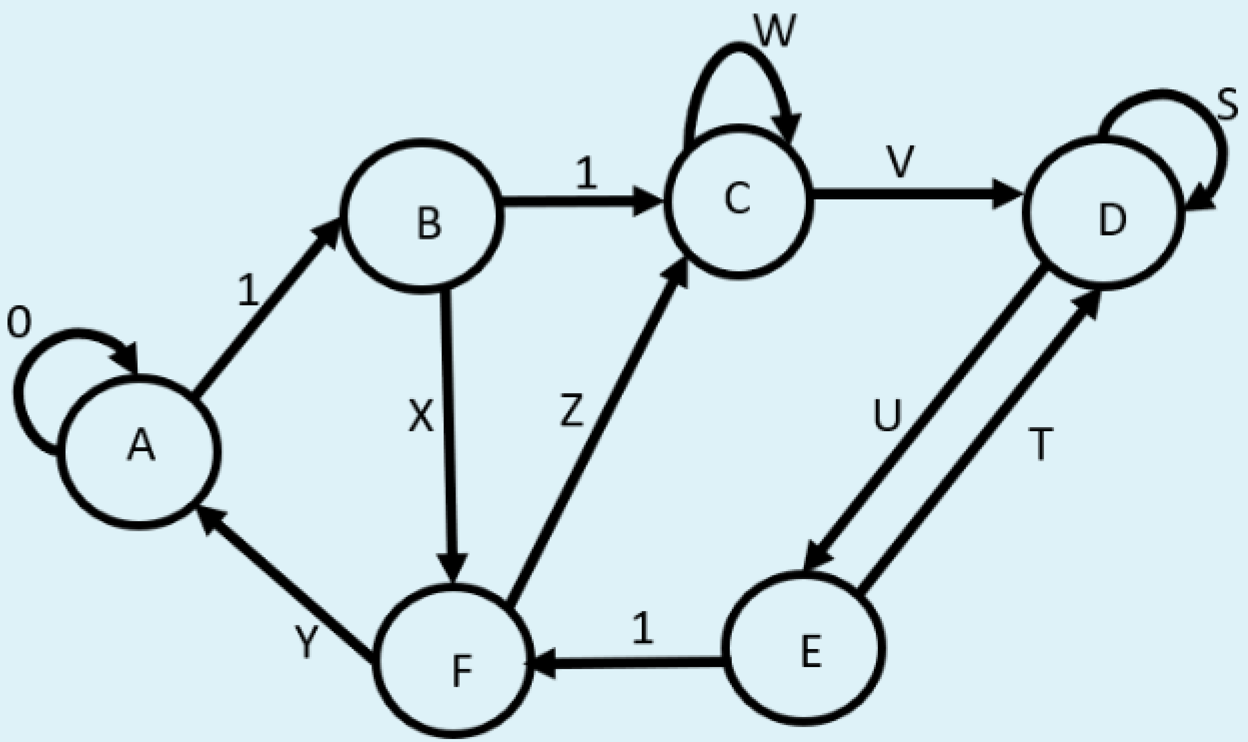
1. If the machine starts in state A, where would it end up with the input 110101? B
2. If the machine starts in state A, where would it end up with the input 1101111? C
3. If the machine starts in state B, where would it end up with the input 111110? D
4. All states except state B have a transition defined for both inputs 0 and 1.

Choose either True or False for each of the following statements.

1. The machine cannot transition out of state C unless it receives an input of 0. True
2. The machine cannot transition out of state A unless it receives an input of 0. False
3. The machine cannot transition out of state B unless it receives an input of 1. True
4. From state D, the machine can never reach state B no matter what the input is. False

Question 28

Given the following state machine diagram with 6 states and 12 transitions, answer the questions that follow.



Choose the correct values for the transitions labelled S - Z given the following facts.

1. Starting in state A, an input sequence of 1010 causes the machine to end up in the same state.
2. Starting in state A, an input sequence of 100001 causes the machine to end up in state D.
3. Starting in state B, an input sequence of 100010 causes the machine to end up in the state E.

S	1	T	0	U	0	V	1
W	0	X	0	Y	1	Z	0